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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

27 Jul 94

MEMORANDUM FOR 9 CES/CEV
ATTN: MS CAROL GAUDETTE

FROM: HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB TX 78235-5357

SUBJECT: Completion of One Year Bioventing Test, Sites 3 and 18

The Air Force Center for Environmental Excellence (AFCEE) one-year bioventing test and evaluation project at Sites 3 and 18 have been completed. Figure 1 provides general site information and Table 1 provides a summary of initial, six-month, and one-year fuel biodegradation rates measured at several monitoring points. Biodegradation rates at Site 3 decreased slightly during the one-year test whereas biodegradation rates at Site 18 remained relatively constant. Table 2 provides a summary of initial and final soil and soil gas sampling results for total recoverable petroleum hydrocarbons (TRPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX). Based on results from your sites and 109 other sites currently under operation, bioventing is cost-effectively remediating fuel contamination in a reasonable time frame. We recommend its application at other sites on your installation using the criteria in the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, May 1992, including Addendum One, February 1994.

The objective of the one-year sampling effort was not to collect the large number of samples required for statistical significance, but to show relative changes in TRPH and BTEX concentrations. Sampling results indicate an order of magnitude reduction in BTEX at VW1-11 and WVM2-11 concerning Sites 3 and 18, respectively. TRPH concentrations decreased at all points except VMP1-9 (Site 3), with a thousand fold decrease at VMP1-12 (Site 18).

Soil gas samples are somewhat similar to composite samples in that they are collected over a wider area. Thus, they provide a good indication of changes in soil gas profiles and volatile contaminant concentrations (see Addendum One to Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine Bioventing Feasibility and Natural Attenuation Potential, February 1994). Soil samples, on the other hand, are discrete point samples subject to large variabilities over small distances/soil types. Given this variability, coupled with known sampling and analytical variabilities, a large number of samples would have to be collected to conclusively determine "real" changes in soil contamination. Because of the limited

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number of samples, these results should not be viewed as conclusive indicators of bioventing progress or evidence of the success or failure of this technology. In situ respiration tests are considered to be better indicators of hydrocarbon remediation than limited soil sampling.

Sampling results indicate that a reduction in TRPH has taken place in the soils within the estimated 30- and 50-foot treatment radius of the pilot vent well at Sites 3 and 18, respectively. Due to the inherent variability of in-situ soil samples, TRPH sampling is inclusive at this time, but all other measurements indicate that fuel biodegradation is progressing at a significant rate. AFCEE recommends that the bioventing pilot systems continue to operate at both sites while planning for a three vent well expansion of the existing system at Site 18. System expansion to a full-scale bioventing system can be contracted through AFCEE. Please contact Sam Taffinder, AFCEE/ERT, DSN 240-4366, commercial 210-536-4366, to discuss technical options for full-scale expansion.

Data from your base and many others indicate that BTEX compounds are preferentially biodegraded over TPH. Since BTEX compounds represent the most toxic and mobile fuel constituents, a BTEX standard is a risk-based standard. We strongly encourage its use over an arbitrary TPH standard. Attachment 3 summarizes the BTEX/TPH issue and a report to be sent under separate cover will assist you in negotiating for a BTEX cleanup standard. Our information indicates that California regulates to BTEX clean-up levels in conjuction with the results from the Design Level Methodology (DLM) on a site-by-site basis. In conclusion, a risk-based approach will expedite site closure while reducing overall costs.

In general, quantitative destruction of BTEX will occur over a one- to two-year bioventing period. Soil gas surveys and respiration tests can be used as BTEX destruction indicators. If a non-risk-based/TPH cleanup is chosen, the pilot and full-scale systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted 4-6 months after background respiration rates are approached.

Because these are streamlined test and evaluation projects, our contract does not provide for additional reports to the base on pilot study results. The interim results report dated Feb 93 contains as-builts and initial data. This letter summarizes all data collected and provides the next step recommendations. AFCEE is no longer responsible for the operation, maintenance, or monitoring of Sites 3 and 18 bioventing systems. We are initiating a contract to extend monitoring at some sites beyond the initial one-year test. Monitoring will include soil gas and respiration tests to document hydrocarbon degradation, but may also include the collection of sufficient final soil samples to statistically demonstrate site cleanup. If you are interested, please call us.

The blower and accessories are now base property and should continue to be used on this or other bioventing sites. Although current equipment is explosion proof, under no circumstances should it be used for soil vapor extraction unless appropriate

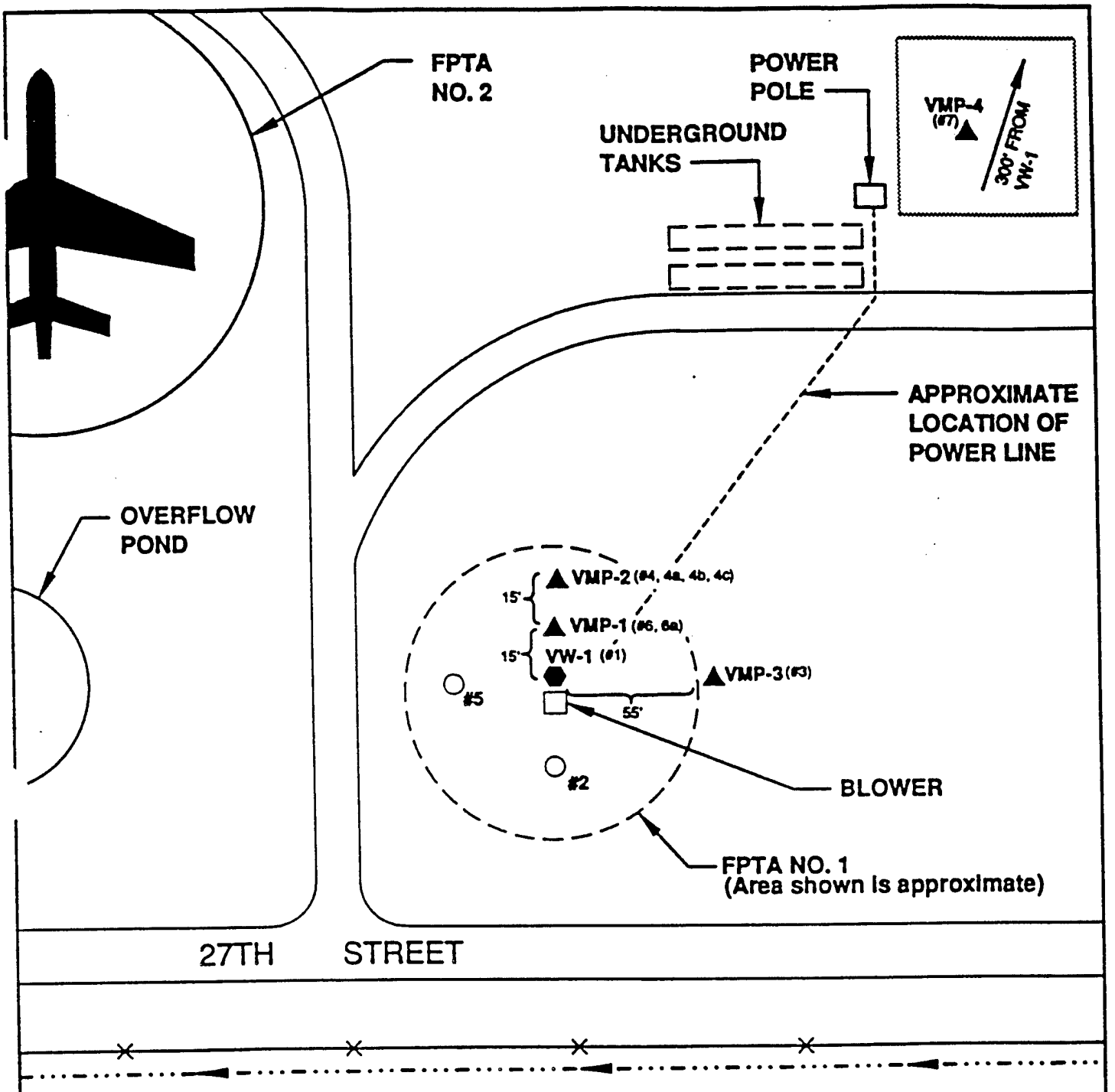
explosion-proof wiring is provided. If the base does not want to keep the blower or if you have further questions, please contact us.

On behalf of the AFCEE/ERT staff, I would like to thank you for your support of these bioventing test and evaluation projects. The information gained from each site will be invaluable in evaluating this technology and will promote its successful application on other DOD, government, and private sites. I have attached a customer satisfaction survey. Please take a few minutes to fill it out and tell us how we did. We look forward to hearing from you.

ROSS N. MILLER, Lt Col, USAF, BSC
Chief, Technology Transfer Division

Attachments:
1. Site 3 Data
2. Site 18 Data
3. "Using Risk-based Standards will Shorten Cleanup Time at Petroleum Contaminated Sites"
4. Survey
5. Addendum One

cc: HQ USAF/CEVR
HQ ACC/CEVR
AFCEE/ERD (Mr. Laborde)



EXPLANATION

⬢ VW-1 (#1)	VW LOCATION (and soil boring number)
▲ VMP-2 (#4)	VMP LOCATION (and soil boring number)
○ #5	ABANDONED SOIL BORING (and soil boring number)

N

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SCALE IN FEET

FIGURE 1

AS-BUILT VW, VMP, AND BLOWER LOCATIONS

IRP SITE 3
FIRE PROTECTION TRAINING AREA NO. 1

BEALE AIR FORCE BASE
CALIFORNIA

CH2-62/2 120992

ENGINEERING-SCIENCE, INC.

TABI
SITE
RESPIRATION AND DEGRADATION RATES
BEALE AFB, CALIFORNIA

Location–Depth	Initial – November 1992			6–Month–July 1993			1–Year–March 1994		
	K_o (%O_2/min)	Degradation Rate (mg/kg/year)/b	Soil Temperature (°C)	K_o (%O_2/min)	Degradation Rate/c (mg/kg/year)	Soil Temperature (°C)	K_o (%O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VMP1–8	NS/a	NS	25.3	0.0039	40	25.1	NS	NS	18.5
VMP1–14	0.0032	170	21.8	0.00013	10	21.7	0.00034	30	21.6
VMP1–24	0.00048	30	NS	0.00012	10	NS	0.00034	40	NS
VMP2–8	NS	NS	NS	NS	NS	NS	NS	NS	NS
VMP2–14	0.0040	210	NS	0.0	0	NS	0.00037	30	NS
VMP2–24	NS	NS	NS	NS	NS	NS	NS	0	NS
VMP3–8	NS	NS	NS	0.00015	0	NS	NS	NS	NS
VMP3–14	NS	NS	NS	0.0	0	NS	NS	NS	NS
VMP3–24	NS	NS	NS	NS	NS	NS	NS	NS	NS
VMP4–8	NS	NS	NS	NS	NS	NS	0.0	NA/d	NS
VMP4–15	NS	NS	NS	NS	NS	NS	0.0	NA	NS
VMP4–24	NS	NS	NS	NS	NS	NS	0.0	NA	NS
VW1	0.0018	90	NS	NS	NS	NS	0.0	0	NS

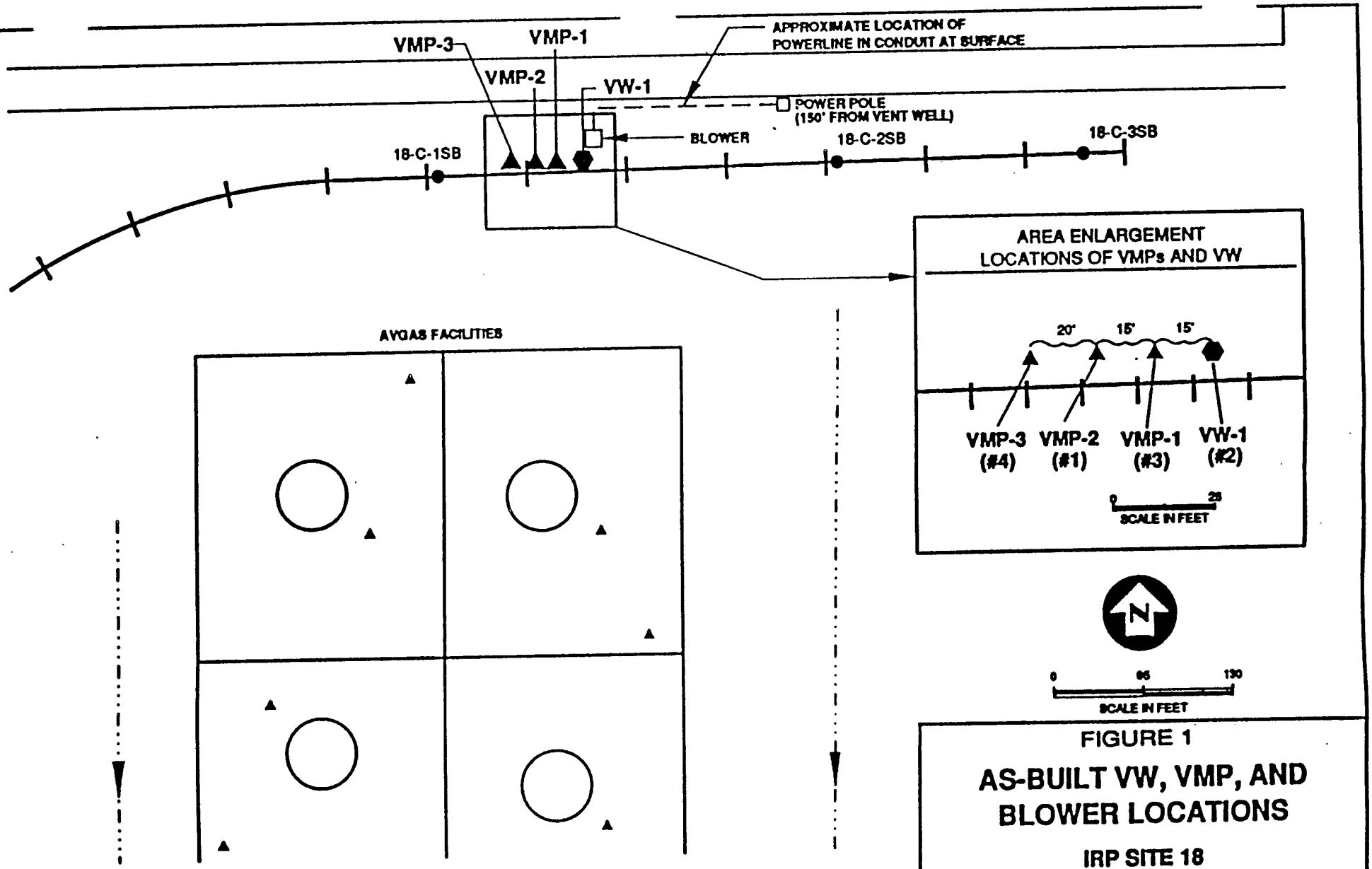
Notes:
/a = Not Sampled.
/b = Milligrams hydrocarbons per kilogram soil per year.
/c = Assumes moisture content of the soil is average of initial and final moistures.
/d = Not Applicable (Background Well).

TABLE 2
SITE 3
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
BEALE AFB, CALIFORNIA

Analyte (Units)[a/]	Sample Locations-Depth (feet below ground surface)					
	VW-1		VMP1-8		VMP3-14	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	4,000	7.4	4,800	780	150	11
Benzene (ppmv)	3.1	<0.002	3.8	0.81	0.054	0.004
Toluene (ppmv)	2.2	<0.002	3.6	1.8	0.016	<0.002
Ethylbenzene (ppmv)	1.4	<0.002	0.72	2.6	<0.002	0.003
Xylenes (ppmv)	3.4	0.002	3.6	5.9	0.002	0.011
	VW1-10		VMP1-9		VMP2-9	
Soil Hydrocarbons	Initial[d/]	1-Year[e/]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	25,000	22,100	7,400	8,010	9,800	41.2
Benzene (mg/kg)	3.2	<0.078	<0.82	<0.32	<1.5	<0.077
Toluene (mg/kg)	8.2	<0.078	3.1	<0.32	3.1	<0.077
Ethylbenzene (mg/kg)	8.2	<0.078	1.7	0.94	<1.3	0.24
Xylenes (mg/kg)	38	0.26	5.8	3.1	7.8	0.76
Moisture (%)	21.8	20.4	27.3	23.0	22.2	19.2

[a/] TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;
TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.
[b/] Initial soil gas samples collected on October 29, 1992.
[c/] Final soil gas samples collected on March 22, 1994.
[d/] Initial soil samples collected on October 19-23, 1992.
[e/] Final soil samples collected on March 15, 1994.

Beale\s3tbl2\brb\6-9-94



EXPLANATION

- 18-C-2SB — PREVIOUS SOIL BORING
- PREVIOUS HAND AUGER SOIL SAMPLE
- VW-1 (#2) — VW LOCATION (and Soil Boring Number)
- VMP-2 (#1) — VMP LOCATION (and Soil Boring Number)
- STORMWATER DRAINAGE
- RAILROAD TRACKS

FIGURE 1

AS-BUILT VW, VMP, AND BLOWER LOCATIONS

IRP SITE 18
BULK FUEL STORAGE AREA
(NORTHERN PORTION)

BEALE AIR FORCE BASE
CALIFORNIA

ENGINEERING-SCIENCE, INC.

TA 1
SI 3

RESPIRATION AND DEGRADATION RATES
BEALE AFB, CALIFORNIA

Location–Depth	Initial – November 1992			6–Month–July 1993			1–Year–January 1994		
	K_o (%O_2/min)	Degradation Rate (mg/kg/year)/b	Soil Temperature (°C)	K_o (%O_2/min)	Degradation Rate/c (mg/kg/year)	Soil Temperature (°C)	K_o (%O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VMP1–6	0.0400	590	21.4	0.0034	400	25.5	0.0035	940	16.1
VMP1–11	0.0048	510	NS	0.00045	50	NS	0.00054	140	NS
VMP1–30	NS/a	NS	NS	0.0	0	NS	0.00017	50	NS
VMP1–65	NS	NS	20.1	NS	NS	19.9	NS	NS	20.5
VMP2–6	NS	NS	NS	0.0029	0	NS	0.0012	10	NS
VMP2–11	0.0037	390	NS	0.00040	0	NS	0.0013	10	NS
VMP2–30	NS	NS	NS	NS	NS	NS	NS	NS	NS
VMP2–65	NS	NS	NS	NS	NS	NS	NS	NS	NS
VMP3–6	NS	NS	NS	0.00049	0	NS	0.0010	10	NS
VMP3–11	NS	NS	NS	0.00020	0	NS	0.00039	0	NS
VMP3–30	NS	NS	NS	0.0	0	NS	0.0	0	NS
VMP3–55	0.00063	0	NS	0.0	0	NS	0.0	0	NS
VW1	NS	NS	NS	NS	NS	NS	0.0	0	NS

Notes:
/a = Not Sampled.
/b = Milligrams hydrocarbons per kilogram soil per year.
/c = Assumes moisture content of the soil is average of initial and final moistures.

TABLE 2
SITE 18
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
BEALE AFB, CALIFORNIA

Analyte (Units)[a/]	Sample Locations-Depth (feet below ground surface)					
	VW-1		VMP1-6		VMP3-6	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	1,500	3.2	1,400	840	7,900	4,100
Benzene (ppmv)	2.0	<0.002	1.1	<0.05	31	14
Toluene (ppmv)	0.65	<0.002	1.1	<0.05	3.0	<0.51
Ethylbenzene (ppmv)	2.1	<0.002	1.2	1.0	2.7	1.4
Xylenes (ppmv)	2.3	<0.002	2.4	1.7	0.76	3.5
	VW1-11		VMP1-12		VMP2-11	
Soil Hydrocarbons	Initial[d/]	1-Year[e/]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	24,000	16,500	40,000	11.7	3,900	354
Benzene (mg/kg)	<1.6	<0.16	<0.41	<0.069	<0.4	<0.17
Toluene (mg/kg)	2.0	<0.16	0.75	<0.069	1.5	<0.17
Ethylbenzene (mg/kg)	6.7	<0.16	0.52	<0.069	2.7	<0.17
Xylenes (mg/kg)	16	<0.23	<0.62	<0.097	7.8	<0.24
Moisture (%)	24.8	24.5	26.9	10.1	26.5	24.8

[a/] TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;
TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram;
[b/] Initial soil gas samples collected on November 12, 1992
[c/] Final soil gas samples collected on January 22, 1994
NS = not sampled
[d/] Initial soil samples collected on November 2-3, 1992
[e/] Final soil samples collected on March 15, 1994